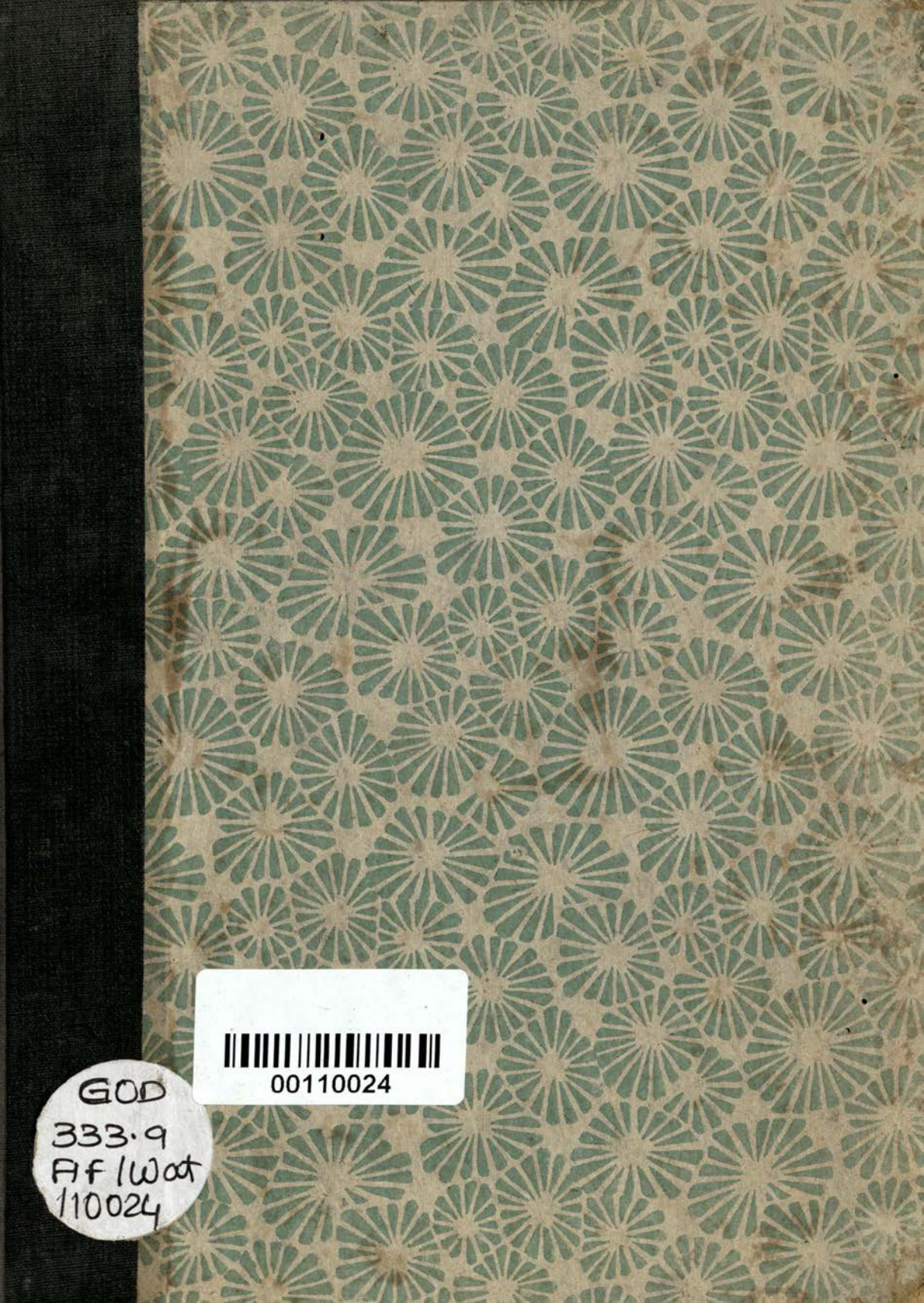

00110024
GOD
333.9
AfIWat
110024

Digitized with financial assistance from

H T Parekh
FOUNDATION

An Initiative by
HDFC
WITH YOU, RIGHT THROUGH

on 27 November, 2018

SELECTIONS FROM THE RECORDS OF THE BOMBAY GOVERNMENT.

IRRIGATION SERIES.—No. II. Vol. II.

WATER SUPPLY

OF

POONA AND KIRKEE

WITH

PLANS AND ESTIMATES.

110024
ac

VOL. II.

PROJECT

BY

LIEUT. COL. FIFE, R.E.

WITH 5 PLANS.

Bombay:
PRINTED FOR GOVERNMENT
AT THE EDUCATION SOCIETY'S PRESS, BYCULLA.

1866.

GOD
333.9
Bom/Wat
110024

MEMORANDUM.

THE following papers regarding the Dam to be erected at Kurrukwasla to form the Reservoir for the Poona Water Supply, refer chiefly to the question of strength as designed by the projector (Lieutenant-Colonel Fife), and also the desirability of increasing the size of it to extend the scheme by irrigating the Indapoor Valley, in addition to the original project of supplying Poona, Kirkee, and Gunnesh Khind with water, and for irrigating 4,000 acres of land between Kurrukwasla and Poona.

4th September 1866. T. DOWDEN.

No. 5904 of 1866.

PUBLIC WORKS DEPARTMENT:

Office of the Superintending Engineer S.D.,
Poona, 7th August 1866.

To the SECRETARY to GOVERNMENT,
Public Works Department, Bombay.

SIR,—I have the honour to forward the accompanying Plan and Estimate received from the Superintending Engineer for Irrigation, for constructing a Dam 88 feet high across the Moola River at Kurrukwasla, and sufficiently thick to admit of its height being hereafter increased so as to supply water for irrigating the Indapoor valley, as well as for the cantonments of Poona and Kirkee, &c.

2. In submitting Lieutenant-Colonel Fife's project, which provides for supplying the Poona and Kirkee Cantonments, the new Arsenal, and Powder Works, and the city of Poona with its environs, only, with water, I remarked, as stated by Lieutenant-Colonel Playfair, on the lightness of Lieutenant-Colonel Fife's section for the Dam, and proposed to increase slightly its dimensions. What action was taken by Government on that proposal I know not, but as my name is in a measure associated with the project, from the fact of my having been called upon to report on it, I respectfully beg that the observations I then made in regard to the dimensions of the dam may, as they cannot now be attached to the report, be circulated among those officers to whom the project has been sent.*

* "2. Lieut.-Colonel Fife's project is in every respect complete, so far as it extends, and his report is so ably written that I feel I should fail to afford further information on the subject were I to attempt to do so. The preliminary investigations, moreover, necessary for the preparation of the designs, have been conducted with so much care, both by Colonel Fife and his assistants, that it is with the greatest diffidence I venture even to remark that Lieutenant-Colonel Fife has perhaps rather over-

3. It will be seen from Lieut.-Colonel Playfair's report that he proposes to build the Dam of a greater width than what has been yet recommended. The formula on which his calculations

---

estimated the strength of the main work (the Dam across the river) and under-rated the cost of portions of the work to be executed in carrying out the scheme.

"3. As regards the strength of the proposed Dam we have no work of similar magnitude from which the requisite dimensions could be decided, and we are therefore obliged to resort to formulæ furnished by different authors. Rankine says that the thickness of a Masonry Dam at bottom should equal six-tenths of the height, and at the top one-fourth of the bottom, and by Moseley's formula the line of least resistance is required to fall 3·75 feet within the point shown on Colonel Fife's section, or in other words the dam at bottom should be within 6" of the width proposed by Rankine. Now the following are the dimensions of Colonel Fife's Dam, and of dams of similar construction as deduced from Rankine's and Moseley's formula :—

	Thickness of Dam at bottom.	Thickness of Dam at top.	
Colonel Fife's calculations ..	46·75	11·6875	When the weight of a cubic foot of masonry = 150 lbs.
Rankine's	51·00	12·75	When the weight of a cubic foot of masonry is 140, as obtained from their tables.
Moseley's	50·50	12·25	
And the dimensions of Colonel Fife's Dam would be increased as shown were the weight of a cubic foot of masonry reduced to 140 lbs.	49·5	12·375	

"4. I am not prepared to say that the Dam as proposed by Lieut.-Colonel Fife is not quite strong enough to resist the pressure of water, and I should not venture to call Lieut.-Colonel Fife's calculations into question, were it not that the fact of the project passing through my hands makes me in a measure responsible for its accuracy.

"5. Considering that the weight of a cubic foot of masonry was found by experiment on a small scale to be from 143 to 148 lbs. it would have been more expedient to have supposed that in a large mass its weight would have diminished rather than increased, and that 140 instead of 150 lbs. would have been the better basis to rest the calculations upon.

"6. I fear from the accompanying statement, showing the rates for the different descriptions of work required in carrying out the project as compared with those which are in use in the offices of the Executive Engineers Poona and Kirkee, and the Poona District, that Colonel Fife's estimates are, as before stated, under-rated, and that the cost of the undertaking will exceed the amount he asks for. As, however, the early submission of the estimate is desired, and Lieut.-Colonel Fife could not be

are based is taken from the *Aide Memoire*, but it does not accord with that given by Moseley and Rankine, both of whose works were published at a much more recent date.

4. The table appended exhibits the difference of opinion entertained on the subject by the authors above named. The question therefore must still be looked upon as one open to discussion, and considering the immense amount of injury failure would occasion, not only to private property, but also to bridges and other

---

communicated with, without causing great delay, I do not consider I should be acting in accordance with the wishes of Government were I to delay the transmission of the project in order to call for further explanation on this head.

"I have, &c,
"C. SCOTT, Lieut.-Colonel, R.E.,
Superintending Engineer S. D.

"*COMPARATIVE STATEMENT of usual Rates throughout the Poona District at which the works are being carried out.*

Description of work.		Colonel Fife's Rates.			Executive Engineer Poona and Kirkee's Rates.			Executive Engineer Poona District's Rates.					
		Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.
Excavation in earth	100 C. F.	0	8	0	0	12	0	0	12	0	1	0	0
Do. in moorum	do.	1	0	0	1	8	0	1	8	0	2	0	0
Do. in rock	do.	4	0	0	7	0	0	4	0	0	7	0	0
Filling in foundation, uncoursed rubble masonry	do.	16	0	0	15	0	0	14	0	0	15	0	0
Superstructure, of coursed rubble masonry, of piers and abutments	do.	20	0	0	30	0	0	22	0	0	30	0	0
Spandril wall, of coursed rubble	do.	20	0	0	30	0	0	25	0	0	35	0	0
Archwork do. including facing voussoirs	do.	40 to 50	0	0	50	0	0	35	0	0	40	0	0
Parapet wall, of coursed rubble masonry	do.	35	0	0	50	0	0	40	0	0	50	0	0
Plastering, of chunam	100 S. F.	5	0	0	8	0	0	8	0	0	9	0	0
Pavement, cut stone 2nd sort	do.	50	0	0	50	0	0	40	0	0	45	0	0
Embankment of earth and moorum	100 C. F.	0	12	0	1	0	0	1	0	0	1	4	0

public buildings, too much attention cannot be paid to the subject, before deciding finally on the section to be adopted.

5. It would be doubtless very desirable, if cost were no object, to construct the Dam of the proportions proposed in the *Aide Memoire*, in order to secure it against any possibility of failure, but I submit that this could scarcely be considered a sufficient reason for incurring so large an expenditure beyond what would be required to execute the work in accordance with the formula given by Rankine and Moseley, unless that formula, which is based on the ascertained weight of a cubic foot of masonry, and the known specific gravity of a cubic foot of water, can be satisfactorily proved to be incorrect. *Vide* page 246 of Rankine's *Applied Mechanics*, and page 442 *Moseley's Mechanical Principles of Engineering and Architecture.*

6. I have ventured on the above remarks as His Excellency is said to have stated that the large project will be *sooner* or *later* carried out. If it is decided to construct the smaller Dam first, I trust that the expediency of increasing the dimensions of the section proposed by Lieut.-Colonel Fife will be again considered before the work is commenced.

I have the honour to be,

Sir,

Your most obedient Servant,

C. SCOTT, Lieut.-Colonel, R.E.,

Superintending Engineer S. D.

STATEMENT showing the thickness of the Dam proposed to be erected at Kurrukwasla, according to different authorities, if 123 or 88 feet in height.

Description of Works.	From *Aid Memoire*, as calculated by Colonel Playfair.			According to Moseley and Rankine.			According to Colonel Fife's calculations.			Remarks.
	Top thickness in feet.	Bottom thickness in feet.	Mean thickness in feet.	Top thickness in feet.	Bottom thickness in feet.	Mean thickness in feet.	Top thickness in feet.	Bottom thickness in feet.	Mean thickness in feet.	
Dimensions of larger Dam	36·00	84·00	60·00	18·00	72·00	45·00	16·50	66·00	41·25	
Probable cost	*Rs. 20,11,984			*Rs. 15,08,987			*Rs. 13,83,035			* The probable amounts here given are those which would be required for expenditure if the Dam were built only to the height proposed for the smaller Dam.
Distance of the point of intersection of the line of resistance with the base from the interior toe of the Dam	51·42 feet.			50·87 feet.			50·41 feet.			
Dimensions of smaller Dam	25·50	59·50	42·50	12·75	51·00	31·87	11·68	45·75	29·21	
Probable cost	Rs. 10,95,383			Rs. 7,59,563			Rs. 7,52,710			
Distance of the point of intersection of the line of resistance with the base from the interior toe of the Dam	26·62 feet.			36·95 feet.			37·51 feet.			

N.B.—The difference in the results obtained from the formulæ given by Moseley and Rankine is inappreciable, indeed the formulæ are similar, except that in one instance the inner side of the Dam is supposed to be vertical, in the other a batter is given to it, as proposed by Colonel Fife.

C. SCOTT, Lieutenant Colonel, R.E.,
Superintending Engineer S. D.

No. 927 of 1866.

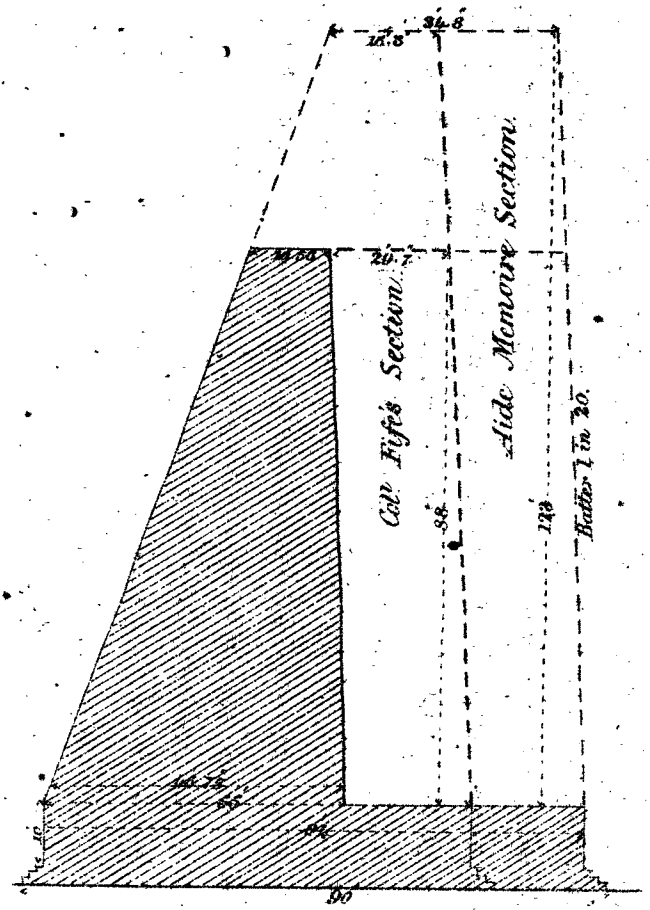
Public Works Department:

Office of Superintending Engineer for Irrigation,
Poona, 30*th July* 1866.

To The SUPERINTENDING ENGINEER,
Southern Division, Poona.

Sir,—In an interview with His Excellency the Governor on the 7th instant, the subject of the Poona Water Supply Project, and its subsequent extension for irrigation, came under discussion.

2. You are aware that the water supply is to be obtained from a lake on the Moota river, to be formed by throwing a Dam 88 feet in height across the valley some miles above Poona, and of a thickness calculated for that height only. Whilst preparing his project for the water supply, it occurred to Colonel Fife that with an additional height of Dam and consequent additional storage, a very valuable Irrigation Canal could be supplied to water the valley on the right bank of the Moota and Bheema rivers; the water supply was, however, urgent; the plans for the irrigation extension would take a long time to prepare, and he therefore sent in the former project complete in itself, merely alluding to the irrigational scheme in a paragraph (No. 36) of his printed report, and recommending that, when carried out, the *foundations* of the water supply Dam should be so increased in dimensions as to answer for the larger Dam, if ever sanctioned; but the extra masonry above the foundations for the larger Dam was to have been added on hereafter to that already supposed to be built, thus:—



The shaded portion representing the masonry required for the Poona Water Supply, with the extra foundation added; the dotted lines showing the extension for the Irrigational scheme.

I may add that though I have in the sketch shown the extra foundation carried out at the same time as the water supply Dam, no provision for its cost is made in the estimate. Colonel Fife merely mentioned it in the paragraph (No. 36) I have quoted, as likely to cost Rs. 1,09,368.

3. On this point His Excellency remarked somewhat to the following effect:—"That there was no doubt a very valuable supply

for Irrigation could be stored up, and that the Irrigation scheme would in consequence certainly be carried out sooner or later, and that it would surely be better to make the Dam for the water supply of such dimensions at once as to admit of its being extended by simply increasing its height, rather than hereafter to be obliged to increase its dimensions from the base upwards by adding old work to new, and incurring the risk of unequal settlement and the want of proper bond between the two portions."

4. Of the advantage of making the Dam of the full thickness required for the Irrigation project at once, merely leaving it to be raised when that project is to be carried out, there can be, I think, but one opinion. I myself most fully concurred; and was then directed to submit an estimate of the probable extra cost of the work, which I have the honour to do herewith. Colonel Fife adopted a very light section for his Poona Water Supply Dam, and intended, I presume, to adopt the same formula when he added to it for the Irrigational one. I have shown his section by a blue line on section No. 19. I myself think that for such a vast work, the usual practical rule should be adopted, and have drawn the sections accordingly; it is very probable that a still greater increase of height may hereafter be found necessary; this could be done perhaps to a moderate extent with the large section when the work was consolidated; it would be very hazardous to do it with Colonel Fife's.

5. The extra cost required to make the Dam of full thickness at once, but only up to Poona water supply height, then, is on Colonel Fife's formula, thus:—

	Rs.
Now estimated	16,61,391
Originally estimated	9,63,432
Extra cost	6,97,959

On the usual practical rule:—

Now estimated	22,23,645
Originally estimated	9,63,432
Extra cost	12,60,213

6. The practical rule I have adopted is given in the *Aide Memoire*, article River and Inland Navigation, page 275, where X being the thickness sought in terms of the height: at the top X = ·30; in the middle X = ·50; and at the bottom X = ·70; and the following remark is taken from the same work:—"Such thicknesses are perhaps rather in excess, but the terrible consequences arising from the bursting of a Dam, and the more perfect impermeability of a large mass of masonry should rather induce a preference in this direction." The lightness of Colonel Fife's section struck you, and you remarked upon it in your No. 8173 of the 21st December 1865, when you forwarded the Water Supply Project on; and with regard to the *Aide Memoire's* remarks, I have only to add that we are going to build—

(1) A Dam above the populous City of Poona, which will be flooded, and probably partially destroyed, should an accident happen to it.

(2) That the height and length of the work is greater than anything known in Europe.

(3) That it is the first work of the kind ever executed in this part of the country, and any accident happening to it would prevent others, so much wanted, being built.

(4) And that therefore it is better to take practical rules deduced from *smaller works* already built, than adopt theoretical ones giving much lighter dimensions to *larger works* than have ever as yet been undertaken.

7. In either estimate the sums are large, and the point on which its sanction will hinge will be whether the profit to be derived from the Irrigation scheme to be eventually carried out will warrant this preliminary expenditure, and there is a fear lest the Supreme Government may hesitate to sanction it, pending the submission of the Irrigational project in a complete form. But the same reason that leads us to press for the sanction of the water supply in the first instance should have weight with the Supreme Government also; this reason being the urgent want of water for the Cantonment and City of Poona, for the Cantonment of Kirkee, and the

new Powder Works, which latter cannot be started till water is available.

8. The Irrigational project is in preparation, and will be sent in as soon as it can be matured, but it involves many difficult questions, and much drawing, calculating, and estimating. The data upon which it is founded are as follows :—

(1) That the lake will fill every year with much less than a minimum flow in the river.

(2) That its contents above the sill of the outlet sluice will, when the Dam is raised to the full height of 123 feet, be—

	C. F.
	8,098,375,000
Deduct—6 feet perpendicular for evaporation	1,052,400,000
Balance.....	7,045,975,000
Add—amount derived from dry weather stream in river.....	993,600,000
	8,039,575,000

Divide this over a space of 7 months, then the perennial discharge will be ..... $\frac{8,039,575,000}{7\times30\times24\times60\times60}$ = 443 c. f. per second

From this to be deducted for Poona and Kirkee Water Supply..... 31 „ „

Leaving .....412 „ „

available for Irrigation for the whole of the dry weather; to this must be added a very considerable monsoon discharge over and above the amount required to fill the Tank, which will be invaluable to the Poona valley, so often liable to drought and famine.

9. The estimate and accompanying sections are very complete, and do not require any further comment. I have myself calculated the position of the line of resistance for the Dam at its extreme height, which calculations are appended to the estimate.

I have the honor to be,

Sir,

Your most obedient Servant,

J. W. PLAYFAIR, Lieut. Colonel, R.E.,
Superintending Engineer for Irrigation.

ESTIMATE No. 2 OF 1866-67.

Poona and Kirkee Water Supply.

PUBLIC WORKS DEPARTMENT:

Office of the Assistant Engineer for Irrigation.

ESTIMATE framed by Lieutenant BUCKLE, R.E., *Assistant Engineer for Irrigation, Poona, of the Probable Cost of constructing the Bund across the River Moota at Kurrukwasla (vide Estimate No. 2 of* 1865-66), *to the level required for the Poona Water Supply Project, but of dimensions sufficient to answer, without alteration, for the larger Irrigation Project.*

IRRIGATION DAM (120 feet).*

Estimate framed agreeably to instructions received from the Superintending Engineer for Irrigation on the 7th July 1866.

Amount of Estimate, Rs. 22,23,645-12-9.

DESCRIPTION.

The length of the Bund and Waste Weir will be the same as that previously estimated, *viz.* bund 2,938 feet, waste weir 1,658 feet. The dimensions of the Dam throughout are such that the top thickness is equal to three-tenths, the bottom thickness seven-tenths, and the mean thickness one-half the height. The waste weir has a mean thickness of half the height, and is perpendicular on the down stream side with a rear batter of one-sixth.

The addition of the large Dam, though it will not alter the length, will alter the position, of the waste weir, which will always be kept at the extremity of the north end of the Dam. It will alter the point of commencement of the waste weir by 605 feet, *i. e.* a length of 605 feet, which in the small Dam will act as a portion

* The Water Supply Dam is 88 feet.

of the waste weir; will afterwards form a portion of the large Dam itself, the additional height making up this length of the weir at its other extremity. This length therefore, or from the 34th to the 37th sections, is calculated as a part of the Dam, though, until the large project is carried out, it will have to act as waste weir.

No other alterations have been made on the original design. The wingwall and the Dam parapet remain as before. Their dimensions, and all details of construction, are given fully in the General Description and Specification of the Dam.

MEASUREMENTS.

Excavation for foundation in Rock.	Numbers.	Length.	Breadth.	Depth.	SOLID FEET.
From 0 to No. 1	1	42	32	1	1,344·00
No. 1 to No. 2	1	24	33·19	1	796·56
No. 2 to No. 3	1	12	35·97	1	431·64
No. 3 to No. 4	1	28	38·72	1	1,084·16
No. 4 to No. 5	1	28	37·94	2	2,124·64
No. 5 to No. 6	1	91	41·90	2	7,625·80
No. 6 to No. 7	1	235	49·82	2·5	29,269·25
No. 7 to No. 8	1	28	56·60	3	4,754·40
No. 8 to No. 9	1	118	60·34	3·5	24,920·42
No. 9 to No. 10	1	14	63·64	4·0	3,563·84
No. 17 to No. 18	1	91	84·55	4·0	30,776·20
No. 18 to No. 19	1	134	90·52	4·0	48,518·72
No. 19 to No. 20	1	26	90·71	4·0	9,433·84
No. 20 to No. 21	1	254	86·4	3·5	76,809·60
No. 21 to No. 22	1	15	80·93	3·0	3,641·85
No. 22 to No. 23	1	23	78·04	3·0	6,384·76
No. 23 to No. 24	1	84	75·39	3·0	18,99·28
No. 24 to No. 25	1	19	71·42	3·0	4,070·94
No. 25 to No. 26	1	90	69·71	3·0	18,821·70
No. 26 to No. 27	1	72	71·33	3·0	15,418·08
No. 27 to No. 28	1	17	70·95	3·0	3,618·45
No. 28 to No. 29	1	133	65·37	3·0	26,032·63
No. 29 to No. 30	1	218	61·56	3·0	40,260·24
No. 30 to No. 31	1	80	60·62	3·0	14,548·80
Carried over	..	..	..	..	393,588·80

Excavation for Foundation in Rock—(continued).	Number.	Length.	Breadth.	Depth.	Solid Feet.
Brought over....	..	..	..	..	393,583·80
From 31 to No. 32	1	239	58·28	3·0	41,796·76
No. 32 to No. 33	1	13	55·57	3·0	2,167·23
No. 33 to No. 34	1	174	53·54	3·0	27,947·88
No. 34 to No. 35	1	160	53·56	3·0	25,708·80
No. 35 to No. 36	1	370	48·89	2·5	45,228·25
No. 36 to No. 37	1	75	44·29	2·0	6,643·50
Total solid feet Excavation in Rock....					543,066·22

Excavation for Foundation in Earth.					
From 0 to No. 1	1	42	32	1·0	1,344·00
No. 1 to No. 2	1	24	33·19	1·0	796·56
No. 2 to No. 3	1	12	35·97	1·0	431·64
No. 3 to No. 4	1	28	38·72	1·0	1,084·16
No. 8 to No. 9	1	118	60·34	5·0	3,560·06
No. 9 to No. 10	1	14	63·64	9·25	82,41·38
No. 10 to No. 11	1	143	66·21	15·75	149,121·47
No. 11 to No. 12	1	20	69·02	19·00	26,227·60
No. 12 to No. 13	1	216	72·16	19·00	296,144·64
No. 13 to No. 14	1	13·00	74·35	19·00	18,364·45
No. 14 to No. 15	1	11	72·05	19·00	15,058·45
No. 15 to No. 16	1	223	72·78	19·00	303,368·86
No. 16 to No. 17	1	13	78·21	16·50	16,776·04
No. 17 to No. 18	1	91	84·55	5·00	38,470·25
No. 19 to No. 20	1	26	90·71	2·00	4,716·92
No. 20 to No. 21	1	254	86·4	4·5	98,755·20
No. 21 to No. 22	1	15	80·93	7·5	9,04·62
No. 22 to No. 23	1	23	78·04	10·0	17,949·20
Carried over....	..	..	..	..	1,014,515·50

Excavation for Foundation in Earth (continued).	Number.	Length.	Breadth.	Depth.	Solid Feet.
Brought over....	..	..	..	..	1,014,515·50
From 23 to No. 24	1	84	75·39	11·0	69,660·36
No. 24 to No. 25	1	19	71·42	13·5	18,319·23
No. 25 to No. 26	1	90	69·71	13·0	80,975·70
No. 26 to No. 27	1	72	71·38	6·5	33,405·84
No. 27 to No. 28	1	17	70·95	4·0	4,824·60
No. 28 to No. 29	1	133	65·37	6·0	52,165·26
No. 29 to No. 30	1	218	61·56	3·0	40,260·24
No. 30 to No. 31	1	80	60·62	1·25	6,062·00
No. 31 to No. 32	1	239	58·28	2·25	31,340·07
No. 32 to No. 33	1	13	55·57	3·25	2,347·83
No. 33 to No. 34	1	174	53·54	3·25	30,276·87
No. 34 to No. 35	1	160	53·56	2·50	21,424·00
No. 35 to No. 36	1	370	48·89	3·00	54,267·90
No. 36 to No. 37	1	75	44·29	3·50	11,626·12
Total solid feet Excavation in Earth.. ...					1,471,471·52

Filling in Foundation with uncoursed Rubble Stone and Chunam.					
From 0 to No. 1, 1st step	1	42	32	1	1,344·00
Ditto 2nd step	1	41	30	1	1,230·00
No. 1 to No. 2, 1st step	1	24	33·19	1	796·56
Ditto 2nd step	1	24	31·19	1	748·56
No. 2 to No. 3, 1st step	1	12	35·97	1	431·64
Ditto 2nd step	1	12	33·97	1	407·64
No. 3 to No. 4, 1st step	1	28	38·72	1	1,084·16
Ditto 2nd step	1	28	36·72	1	1,028·16
No. 4 to No. 5, 1st step	1	28	37·94	1	1,062·32
Ditto 2nd step	1	28	35·94	1	1,006·32
No. 5 to No. 6, 1st step	1	91	41·90	1	3,812·90
Ditto 2nd step	1	91	39·90	1	3,630·90
No. 6 to No. 7, 1st step	1	235	49·82	1·5	17,561·55
Ditto 2nd step	1	235	46·82	1·0	11,002·70
Carried over....	..	..	..	..	45,147·41

Filling in Foundation with uncoursed Rubble Stone and Chunam—(continued).	Number.	Length.	Breadth.	Depth.	Solid Feet.
Brought over	..	..	..	..	45,147·41
From 7 to No. 8, 1st step	1	28	56·60	1·0	1,584·80
Ditto 2nd step	1	28	54·60	1·0	1,528·80
Ditto 3rd step	1	28	52·60	1·0	1,472·80
No. 8 to No. 9, 1st step	1	118	60·34	1·5	10,680·18
Ditto 2nd step	1	118	57·84	1·0	6,766·12
Ditto 3rd step	1	118	55·34	1.0	6,560·12
Ditto 4th step	1	118	53·34	5·0	31,470·60
No. 9 to No. 10, 1st step	1	14	63·64	1·0	850·96
Ditto 2nd step	1	14	61·64	1·0	862·96
Ditto 3rd step	1	14	59·64	1·0	834·96
Ditto 4th step	1	14	57·64	1·0	806·96
Ditto 5th step	1	14	55·64	9·25	7,205·38
No. 10 to No. 11, 1st step	1	143	66·21	1·0	9,468·03
Ditto 2nd step	1	143	64·21	1·0	9,182·03
Ditto 3rd step	1	143	62·21	1·0	8,896·03
Ditto 4th step	1	143	60·21	1·0	8,610·03
Ditto 5th step	1	143	58·21	11·75	97,807·35
No. 11 to No. 12, 1st step	1	20	69·02	1·0	1,380·40
Ditto 2nd step	1	20	67·02	1·0	1,340·40
Ditto 3rd step	1	20	65·02	1·0	1,300·40
Ditto 4th step	1	20	63·02	1·0	1,260·40
Ditto 5th step	1	20	61·02	15·0	18,306·00
No. 12 to No. 13, 1st step	1	216	72·16	1·0	15,586·56
Ditto 2nd step	1	216	70·16	1·0	15,154·56
Ditto 3rd step	1	216	68·16	1·0	14,722·56
Ditto 4th step	1	216	66·16	1·0	14,290·56
Ditto 5th step	1	216	64·16	15·0	207,878·40
No. 13 to No. 14, 1st step	1	13	74·35	1·0	966·56
Ditto 2nd step	1	13	72·35	1·0	940·55
Ditto 3rd step	1	13	70·35	1·0	914·55
Ditto 4th step	1	13	68·35	1·0	888·55
Ditto 5th step	1	13	66·35	15·0	12,938·25
No. 14 to No. 15, 1st step	1	11	72·05	1·0	792·55
Ditto 2nd step	1	11	70·05	1·0	770·55
Ditto 3rd step	1	11	68·05	1·0	748·55
Ditto 4th step	1	11	66·05	1·0	726·55
Ditto 5th step	1	11	64·05	15·0	10,568·25
Carried over	..	..	..	..	571,210·67

Filling in Foundation with uncoursed Rubble Stone and Chunam—(continued).	Number.	Length.	Breadth.	Depth.	Solid Feet.
Brought over....	..	..	..	..	571,210·67
From 15 to No. 16, 1st step	1	223	72·78	1·0	16,229·94
Ditto 2nd step	1	223	70·78	1·0	15,783·94
Ditto 3rd step	1	223	68·78	1·0	15,337·94
Ditto 4th step	1	223	66·78	1·0	14,891·94
Ditto 5th step	1	223	64·78	15·0	210,089·10
No. 16 to No. 17, 1st step	1	13	78·21	1·0	1,016·73
Ditto 2nd step	1	13	76·21	1·0	990·73
Ditto 3rd step	1	13	74·21	1·0	964·73
Ditto 4th step	1	13	72·21	1·0	938·73
Ditto 5th step	1	13	70·21	12·5	11,409·12
No. 17 to No. 18, 1st step	1	91	84·55	1·0	7,694·05
Ditto 2nd step	1	91	82·55	1·0	7,512·05
Ditto 3rd step	1	91	80·55	1·0	7,330·05
Ditto 4th step	1	91	78·55	1·0	7,148·05
Ditto 5th step	1	91	76·55	5·0	34,830·25
No. 18 to No. 19, 1st step	1	134	90·52	1·0	12,129·68
Ditto 2nd step	1	134	88·52	1·0	11,861·68
Ditto 3rd step	1	134	86·52	1·0	11,593·68
Ditto 4th step	1	134	84·52	1·0	11,325·68
No. 19 to No. 20, 1st step	1	26	90·71	1·0	2,358·46
Ditto 2nd step	1	26	88·71	1·0	2,306·46
Ditto 3rd step	1	26	86·71	1·0	2,254·46
Ditto 4th step	1	26	84·71	1·0	2,202·46
Ditto 5th step	1	26	82·71	2·0	4,300·92
No. 20 to No. 21, 1st step	1	254	86·4	1·5	34,418·40
Ditto 2nd step	1	254	83·4	1·0	21,193·60
Ditto 3rd step	1	254	81·4	1·0	20,675·60
Ditto 4th step	1	254	79·4	4·5	90,754·20
No. 21 to No. 22, 1st step	1	15	80·93	1·0	1,213·95
Ditto 2nd step	1	15	78·93	1·0	1,183·95
Ditto 3rd step	1	15	76·93	1·0	1,153·95
Ditto 4th step	1	15	74·93	7·5	8,429·62
No. 22 to No. 23, 1st step	1	23	78·04	1·0	1,794·92
Ditto 2nd step	1	23	76·04	1·0	1,748·92
Ditto 3rd step	1	23	74·04	1·0	1,702·92
Ditto 4th step	1	23	72·04	10·0	16,569·20
No. 23 to No. 24, 1st step	1	84	75·39	1·0	6,332·76
Ditto 2nd step	1	84	73·39	1·0	6,164·76
Ditto 3rd step	1	84	71·39	1·0	5,996·76
Ditto 4th step	1	84	69·39	11·0	64,116·36
Carried over....	..	..	..	..	1,267,160·27

Filling in Foundation with uncoursed Rubble Stone and Chunam— (continued).	Numbers.	Length.	Breadth.	Depth.	Solid Feet.
Brought over....	..	..	..	..	1,267,160·27
From 24 to No. 25, 1st step	1	19	71·42	1·0	1,356·98
Ditto 2nd step	1	19	69·42	1·0	1,318·98
Ditto 3rd step	1	19	67·42	1·0	1,280·98
Ditto 4th step	1	19	65·42	13·5	16,780 23
No. 25 to No. 26, 1st step	1	90	69·71	1·0	6,273·90
Ditto 2nd step	1	90	67·71	1·0	6,093·90
Ditto 3rd step	1	90	65·71	1·0	5,913·90
Ditto 4th step	1	90	63·71	13·0	84,540·70
No. 26 to No. 27, 1st step	1	72	71·38	1·0	5,139·36
Ditto 2nd step	1	72	69·38	1·0	4,995·36
Ditto 3rd step	1	72	67·38	1·0	4,851·36
Ditto 4th step	1	72	65·38	6·5	30,597·84
No. 27 to No. 28, 1st step	1	17	70·95	1·0	1,206·15
Ditto 2nd step	1	17	68·95	1·0	1,172·15
Ditto 3rd step	1	17	66·95	1·0	1,138·15
Ditto 4th step	1	17	64·95	4·0	4,416·60
No. 28 to No. 29, 1st step	1	133	65·37	1·0	8,694·21
Ditto 2nd step	1	133	63·37	1·0	8,428·21
Ditto 3rd step	1	133	61·37	1·0	8,162·21
Ditto 4th step	1	133	59·37	6·0	47,377·26
No. 29 to No. 30, 1st step	1	218	61·56	1·0	13,420·08
Ditto 2nd step	1	218	59·56	1·0	12,984·08
Ditto 3rd step	1	218	57·56	1·0	12,548.08
Ditto 4th step	1	218	55·56	3·0	36,336·24
No. 30 to No. 31, 1st step	1	80	60·62	1·0	4,849·60
Ditto 2nd step	1	80	58·62	1·0	4,689·60
Ditto 3rd step	1	80	56·62	1·0	4,529·60
Ditto 4th step	1	80	54·62	1·25	5,462·00
No. 31 to No. 32, 1st step	1	239	58·28	1·0	13,928·92
Ditto 2nd step	1	239	56·28	1·0	13,450·92
Ditto 3rd step	1	239	54·28	1·0	12,972·92
Ditto 4th step	1	239	52·28	2·25	28,113·57
No. 32 to No. 33, 1st step	1	13	55·57	1·0	722·41
Ditto 2nd step	1	13	53·57	1·0	696·41
Ditto 3rd step	1	13	51·57	1·0	670·41
Ditto 4th step	1	13	49·57	3·25	2,094·33
No. 33 to No. 34, 1st step	1	174	53·54	1·0	9,315·96
Ditto 2nd step	1	174	51·54	1·0	8,967·96
Ditto 3rd step	1	174	49·54	1·0	8,619·96
Ditto 4th step	1	174	47·54	3·25	26,883·87
Carried over....	..	..	..	..	1,738,155·62

Filling in Foundation with uncoursed Rubble Stone and Chunam—(continued).	Number.	Length.	Breadth.	Depth.	Solid Feet.
Brought forward....	..	..	..	..	1,738,155·62
From 34 to No. 35, 1st step	1	160	53·56	1·0	8,569·60
Ditto 2nd step	1	160	51·56	1·0	8,249·60
Ditto 3rd step	1	160	49·56	1·0	7,929·60
No. 35 to No. 36, 1st step	1	370	48·89	1·5	27,133·95
Ditto 2nd step	1	370	45·89	1·0	16,979·30
No. 36 to No. 37, 1st step	1	75	44·29	1·0	3,321·75
Ditto 2nd step	1	75	42·29	1·0	3,171·75
Total solid feet filling in Foundation....					1,813,511·17

Superstructure of coursed Rubble Masonry and Chunam.	Number.	Lenght.	Mean Area.	Solid Feet.
From 0 to No. 1	1	40	105·60	4,224·00
No. 1 to No. 2	1	24	265·77	6,378·48
No. 2 to No. 3	1	12	202·37	2,423·44
No. 3 to No. 4	1	23	468·00	13,048·00
No. 4 to No. 5	1	28	506·40	14,179·20
No. 5 to No. 6	1	91	750·08	68,257·28
No. 6 to No. 7	1	235	1,247·27	293,103·45
No. 7 to No. 8	1	28	1,717·65	48,094·20
No. 8 to No. 9	1	118	1,968·65	232,300·70
No. 9 to No. 10	1	14	2,193·67	30,711·33
No. 10 to No. 11	1	143	2,456·10	351,222·30
No. 11 to No. 12	1	20	2,761·23	55,224·60
No. 12 to No. 13	1	216	3,118·62	673,621·92
No. 13 to No. 14	1	13	3,377·88	43,912·44
No. 14 to No. 15	1	11	3,111·93	34,231·23
No. 15 to No. 16	1	223	3,203·59	714,400·57
No. 16 to No. 17	1	13	3,865·80	50,255·40
No. 17 to No. 18	1	91	4,747·21	431,996·11
No. 18 to No. 19	1	134	5,621·94	793,539·96
No. 19 to No. 20	1	26	5,620·72	146,138·72
Carried forward.....	..	..	....	4,007,273·38

Superstructure of coursed Rubble Masonry and Chunam—(continued).	Number.	Length.	Mean area.		Solid Feet.
Brought forward	..	..	....		4,007,273·58
No. 20 to No. 21	1	254	5,120·70		1,300,657·80
No. 21 to No. 22	1	15	4,503·27		67,549·05
No. 22 to No. 23	1	23	4,103·46		94,379·38
No. 23 to No. 24	1	84	3,765·08		316,266·72
No. 24 to No. 25	1	19	3,271·50		62,158·50
No. 25 to No. 26	1	90	3,063·58		275,722·20
No. 26 to No. 27	1	72	3,261·21		234,807·12
No. 27 to No. 28	1	17	3,211·47		31,594·97
No. 28 to No. 29	1	133	2,590·68		344,560·44
No 29 to No. 30	1	218	2,183·70		476,046·60
No. 30 to No. 31	1	80	2,091·26		167,300·80
No. 31 to No. 32	1	239	1,869·58		446,829·62
No. 32 to No. 33	1	13	1,623·36		21,103·68
No. 33 to No. 34	1	174	1,450·85		252,360·90
No. 34 to No. 35	1	160	1,173·29		187,726·40
No. 35 to No. 36	1	370	904·29		334,587·30
No. 36 to No. 37	1	75	646·18		48,463·50
			Breadth.	Depth.	
Parapet	1	2,939	3	2	17,634·00
Total solid feet					8,680,022·36
Deduct—Masonry occupied by Sluice, *vide* estimate of Sluice ..					8,218·80
Total cubic feet Superstructure, Small Dam					8,671,803·56

Superficial Feet facing of Rock Ashlar.	Number.	Length.	Breadth.	Superficial Feet.
From 0 to No. 1	1	40	4	160·00
No. 1 to No. 2	1	24	9·7	232·80
No. 2 to No. 3	1	12	13·68	164·16
No. 3 to No. 4	1	28	15·47	433·16
No. 4 to No. 5	1	28	16·49	461·72
No. 5 to No. 6	1	91	22·15	2,015·65
No. 6 to No. 7	1	235	32·04	7,529·40
No. 7 to No. 8	1	28	40·3	1,128·40
No. 8 to No. 9	1	118	44·22	5,217·96
No. 9 to No. 10	1	14	47·5	665·00
No. 10 to No. 11	1	143	51·16	7,315·88
No. 11 to No. 12	1	20	55·19	1,103·80
No. 12 to No. 13	1	216	59·67	12,888·72
No. 13 to No. 14	1	13	62·79	816·27
No. 14 to No. 15	1	11	59·51	654·61
No. 15 to No. 16	1	223	60·56	13,504·88
No. 16 to No. 17	1	13	68·31	888·03
No. 17 to No. 18	1	91	77·37	7,040·67
No. 18 to No. 19	1	134	85·96	11,518·64
No. 19 to No. 20	1	26	86·17	2,240·42
No. 20 to No. 21	1	254	81·44	20,685·76
No. 21 to No. 22	1	15	75·15	1,127·25
No. 22 to No. 23	1	23	70·92	1,631·16
No. 23 to No. 24	1	84	67·14	5,639·76
No. 24 to No. 25	1	19	61·47	1,167·93
No. 25 to No. 26	1	90	59·02	5,311·80
No. 26 to No. 27	1	72	61·37	4,418·64
No. 27 to No. 28	1	17	60·76	1,032·92
No. 28 to No. 29	1	133	52·82	7,025·06
No. 29 to No. 30	1	218	47·33	10,328·84
No. 30 to No. 31	1	80	46·04	3,683·20
No. 31 to No. 32	1	239	42·69	10,202·91
No. 32 to No. 33	1	13	38·82	504·66
No. 33 to No. 34	1	174	35·92	6,250·08
No. 34 to No. 35	1	160	27·95	4,472·00
No. 35 to No. 36	1	370	22·7	8,399·00
No. 36 to No. 37	1	75	17·57	1,317·75
			Total....	169,178·89
Deduct—Opening of sluices				70·00
Total superficial feet Rock Ashlar...				169,108·89

Cut-stone Coping (*3rd sort*).

	Number.	Length.	Breadth.	Height.	Solid Feet.
From No. 34 to No. 35	1	160	36·39	1	2,911·20
„ No. 35 to No. 36	1	370	34·81	1	6,439·85
„ No. 36 to No. 37	1	75	33·27	1	1,247·64
Parapet	1	29·39	(1·571)		4,614·17
Total cubic feet cut-stone Coping.....					15,215·86

Sluices, Poona side.

	No.	L.	B.	H.	Solid Feet.
Coursed Rubble Masonry and Chunam, to be deducted from the Masonry of Dam.					
Up to the height of extradoes of Sluice Arches.....	1	37·7	27	4·5	4,580·55
Total Deduction.....					4,580·55

	No.	L.	B.	H.	Solid Feet.
Superstructure for Sluices.					
Up to the height of extradoes..	1	38½	27	4·5	4,677·75
Over projecting parts of the Arches.	..	27	1·78	1	48·06
Carried over....					4,725·81

Superstructure—continued.	Number.	Length.	Breadth.	Height.	Solid Feet.
Brought over	..	..	..	..	4,725·81
Deduct—					
Openings rectangular	4	38·5	3	3	1,386
Do. circular portion	4	38·5	area (1·021)		157·23
Arch-work	4	38·5	*m* 3·6331	1	559·50
Total Deduction...					2,103·73
Total Superstructure					2,622·08

	No.	L.	B.	H.	Solid Feet.
Arch-work.					
Arches	4	38·5	*m* 3·6331	1	559·5
Total Arch-work					559·5

	No.	L.	Total Running Feet.
Grooves.			
For the shutters, two sides	2	7	14
Bottom and top	2	3·5	7
Total.....			21
Add for 3 more			63
Total.....			84

Teak-wood.	Number.	Length.	Breadth.	Height.	Solid Feet.
Teak rods	4	23	0·25	0·25	5·75
		area			
Teak planks	4	14·26		25	14·26
Total					20·01
Add one-fourth for wastage					5
Total					25

Chain, Iron.	No.	L.	Running Feet.
Chain	4	8	32

Crabwinch, double.	No.
Crabwinch, double	1

Centering.	No.	L.	B.	H.	Solid Feet.
Rectangular portion	4	38·5	3	3	1,386·00
		area			
Circular	4	(1·021)		38·5	157·23
Total cubic feet Centering					1,543·23

Sluice, Kirkee Side.

Coursed Rubble Masonry and Chunam, to be deducted from the Masonry of Dam.	Number.	Length.	Breadth.	Depth.	Solid Feet.
		m			
Up to the height of extradoes of sluice arches	1	38·5	21	4·5	3,638·25
Total Deduction.....					3,638·25

	No.	L.	B.	H.	Solid Feet.
Superstructure for sluices up to the height of extradoes		39·4	21	4·5	3,723·30
Over projecting parts of the arches.	1	21	1·75	1	36·75
Total Carried over.....					3,760·05

Deduct—	N.	L.	B.	H.	Solid Feet.
Openings, rectangular	3	39·4	3	3	1,063·80
			Area.		
„ Circular portion	3	39·4	1·021		120·68
„ Arch-work	3	39·4	3·6331	1	439·43
Total deduction.....					1,623·91
Total Superstructure.....					2,136·14

Arch-work.	No.	L.	B.	H.	Solid Feet.
			m		
Arches	3	39·4	3·6331	1	439·43

Grooves.

	Number.	Length.	Running Feet.
For the shutters, two sides	2	7	4
Bottom and top	2	3·5	7
Total			21
Add for two more			42
Total			63

Teak-wood.

	No.	L.	B.	H.	Solid Feet.
Teak rods	3	·25	·25	·15	2·81
		Area.			
Teak planks	3	14·26		·25	10·69
Total					13·50
Add one-fourth for wastage					3·37
Total					16·87

	No.	L.	Running Feet.
Chain, Iron	3	8	24

	No.
Crabwinch, double	1

Centerings.	Number.	Length.	Breadth.	Depth.	Solid Feet.
Rectangular portion	3	39·4	3	3	1,063·80
		Area.			
Circular portion.....	3	1·021		39·4	120·68
				Total.....	1,184·48

ABSTRACT OF SLUICE, POONA SIDE.

Quantities.	Items.	Amount. Rs.	a.	p.
2,622	Solid feet superstructure, at Rs. 18 per 100 solid feet	471	15	4
559	Solid feet arching, at Rs. 40 per ditto	223	9	7
84	Running feet cut grooves, at Rs. 2 per foot	168	0	0
25	Cubic feet teakwood, for gate, at Rs. 6 per foot..	150	0	0
32	Running feet iron chain, at Rs. 1-8 per ditto ..	48	0	0
1	Crabwinch, double, at Rs. 170 each	170	0	0
1,543	Solid feet masonry, for centering, at Rs. 16 per 100 solid feet	246	13	0
	Total of Poona side....	1,477	8	11

ABSTRACT OF SLUICE, KIRKEE SIDE.

Quantities.	Items.	Amount.		
		Rs.	a.	p.
2,136	Solid feet superstructure, at Rs. 18 per 100 solid feet	384	7	8
439	Solid feet arching, at Rs. 40 per ditto	175	9	7
63	Running feet cut grooves, at Rs. 2 per foot	126	0	0
17	Cubic feet teakwood, for gate, at Rs. 6 per foot	102	0	0
24	Running feet chain, iron, at Rs. 1·8 per ditto	36	0	0
1	Crabwinck, double, at Rs. 170 each	170	0	0
1,184	Solid feet masonry, for centering, at Rs. 16 per 100 solid feet	189	7	0
	Total Rupees for Kirkee side....	1,183	8	3

ABSTRACT—SMALL DAM.

Quantities.	Items.	Amount.		
		Rs.	a.	p.
543,066	Cubic feet excavation for foundation in rock, at Rs. 7 per 100 cubic feet	38,014	9	11
1,545,844	Cubic feet ditto ditto in earth, at 1 rupee per ditto	15,458	7	0
1,810,454	Ditto filling in foundation with rubble, coursed, and chunam, at Rs. 15 per ditto	2,71,568	1	4
8,709,474	Ditto superstructure of coursed rubble masonry and chunam, at Rs. 18 per ditto	15,67,705	5	1
146,403	Superficial feet rock ashlar, at Rs. 28 per 100 superficial feet	4,099	4	6
15,216	Cubic feet cut stone coping, of 3rd sort, at Rs. 75 per 100 cubic feet	11,412	0	0
	Sluice Poona side, *vide* Estimate	1,477	8	11
	Ditto Kirkee ditto	1,183	8	3
	Total....	19,10,918	12	8
	Add contingencies at 5 per cent.	95,545	15	0
	Carried forward....Rupees	20,06,464	11	8

ABSTRACT—SMALL DAM—*continued.*

	Amount.		
	Rs.	a.	p.
Brought forward....	20,06,464	11	8
Extra Establishment:—			
4 Carcoons for 2 years, at Rs. 20 per month.....	1,920	0	0
2 ditto for ditto, at Rs. 15 ditto	720	0	0
2 ditto for ditto, at Rs. 12 ditto	576	0	0
8 Muckadums at Rs. 10 per month	1,920	0	0
2 Chowkeedars, at Rs. 8 ditto	384	0	0
Total....Rupees	5,520	0	0
Grand Total....Rupees	20,11,984	11	8

WASTE WEIR.

Excavation for Foundation in Rock.	Number.	Length.	Breadth.	Depth.	Solid Feet.
From No. 37 to No. 38	1	138	34·42	2·0	9,499·92
No. 38 to No. 39	1	295	31·85	2·0	18,791·50
No. 39 to No. 40	1	366	29·52	2·0	21,608·64
No. 40 to No. 41	1	108	28·64	2·0	6,186·24
No. 41 to 0	1	146	27·84	2·0	8,129·28
Total solid feet Excavation in Rock....					64,215·58

Excavation in Earth.	Number.	Length.	Breadth.	Depth.	Solid Feet.
From No. 37 to No. 38	1	138	30·22	5·82	24,271·49
No 38 to No. 39	1	295	27·85	4·71	38,696·18
No. 39 to No. 40	1	366	25·52	3·24	30,262·63
No. 40 to No. 41	1	108	24·64	5·35	14,236·99
No. 41 to 0	1	146	23·84	7·83	27,253·41
Total solid feet Excavation in Earth....					134,720·70

Filling in Foundation with Rubble and Chunam.					
From No. 37 to No. 38, 1st step..	1	138	34·42	1·0	4,749·96
Do. do. 2nd do...	1	138	32·42	1·0	4,473·96
From No. 38 to No. 39, 1st step..	1	295	31·85	1·0	9,395·75
Do. do. 2nd do...	1	295	29·85	1·0	8,805·75
From No. 39 to No. 40, 1st step..	1	366	29·52	1·0	10,804·32
Do. do. 2nd do...	1	366	27·52	1·0	10,072·32
From No. 40 to No. 41, 1st step..	1	108	28·64	1·0	3,093·12
Do. do. 2nd do...	1	108	26·64	1·0	2,877·12
From No. 41 to 0, 1st step	1	146	27·84	1·0	4,064·64
Do. do. 2nd do.....	1	146	25·84	1·0	3,772·64
Total solid feet filling in.....					62,109·58

Superstructure of coursed Rubble and Chunam.	Number.	Length.	Area.	Superficial Feet.
No. 37 to No. 38	1	138	479·69	66,197·22
No. 38 to No. 39	1	295	343·58	101,356·10
No. 39 to No. 40	1	366	217·19	79,491·54
No. 40 to No. 41	1	108	175·32	18,934·56
No. 41 to 0	1	146	137·56	20,083·76
Total Superstructure....				286,063·18

Facing of Rock Ashlar Masonry.	Number.	Length.	Breadth.	Superficial Feet.
No. 37 to No. 38	1	138	16·82	2,321·16
No. 38 to No. 39	1	295	12·75	3,761·25
No. 39 to No. 40	1	366	8·76	3,206·16
No. 40 to No. 41	1	108	7·26	784·08
No. 41 to 0	1	146	3·00	438·00
Total superficial feet Rock Ashlar Masonry....				10,510·65

Coping of 3rd sort Cut-stone.					
From No. 37 to No. 38	1	138	$\frac{27·42}{2}$	1	1,891·98
No. 38 to No. 39	1	295	$\frac{25·73}{2}$	1	3,795·17
No. 39 to No. 40	1	366	$\frac{24·06}{2}$	1	4,402·98
No. 40 to No. 41	1	108	$\frac{23·44}{2}$	1	1,265·76
No. 41 to No. 0	1	146	$\frac{22·87}{2}$	1	1,669·51
Total cubic feet Coping.....					13,025·40

Wing Wall at the end of the Waste Weir.					
Excavation for foundations—		*m.*			
Middle portion	1	17·86	12	11·68	2,503·25
End portions	2	39·93	14	11·68	13,058·71
Total cubic feet Excavation.....					15,561·96

Deduct—	Number.	Length.	Breadth.	Depth.	Solid Feet.
Portions calculated in excess	2	2·165	$\frac{2·6134}{2}$	11·68	66·08
Total cubic feet Excavation for foundation.....					15,495·88

Filling in Foundations.					
Middle portion, 1st step	1	17·86	12	1	214·32
Ditto 2nd do.	1	18·274	11	1	201·01
		m.			
End portions, 1st step	2	39·93	14	1	1,118·04
Ditto 2nd do.	2	38·93	12	1	934·32
Total cubic feet Foundations.....					2,467·69

Deduct—					
Masonry calculated in excess, 1st step	2	21·65	$\frac{2·6134}{2}$	1	56·58
Ditto do. do. 2nd step ..	2	($\frac{1}{4}$ of the above result.)			14·15
Total deduction.....					70·73
Total cubic feet filling in Foundations..					2,396·96

Superstructure.	Number.	Length.	Breadth.	Depth.	Solid Feet.
		m.	m.		
Middle portion	1	19·38	7·125	13·78	1,903·01
		m.	m.		
End portions	2	36·53	7·125	13·78	7,173·18
Junction triangular portions of waste weir with the wings.....	2	·95	$\frac{·95}{2}$	$\frac{5.78}{2}$	2·60
Total Superstructure.....					9,078·79

ABSTRACT OF WASTE WEIR.

Quantities.	Items.	Amount. Rs.	a.	p.
64,216	Cubic feet excavation in rock, at Rs. 7 per 100 cubic feet	4,495	1	11
134,720	Do. do. in earth, at Rs. 1 per ditto	1,347	3	2
62,110	Do. filling in foundation, at Rs. 15 per do.....	9,316	8	0
286,063	Do. superstructure, at Rs. 18 per do.	51,491	5	5
10,511	Superficial feet rock ashlar, at Rs. 28 per 100 superficial feet	2,943	1	3
13,025	Cubic feet coping, cutstone, 3rd sort, at Rs. 75 per 100 cubic feet	9,768	12	0
	Total....Rupees	79,361	15	9
	Add contingencies at 5 per cent.	3,968	1	7
	Total cost of Waste Weir.....	83,330	1	4
	Establishment.....	1,032	0	0
	Grand Total.....Rupees	84,362	1	4

ABSTRACT OF WING WALL.

Quantities.	Items.	Amount. Rs. a. p.
15,496	Cubic feet excavation for foundation in earth, at Rs. 1 per 100 cubic feet	154 15 4
2,397	Do. filling in foundation, at Rs. 15 per do.	359 8 9
9,079	Do. superstructure, at Rs. 18 per do.	1,634 3 6
	Total....Rupees	2,148 11 7
	Add contingencies at 5 per cent.	107 6 11
	Total....Rupees	2,256 2 6
1	Carkoon for 4 months, at Rs. 16 per month	60 0 0
1	Muckadum for 4 months, at Rs. 10	40 0 0
	Total....Rupees	2,356 2 6

RECAPITULATION.

	Rs. a. p.
Cost of Land	77,800 0 0
Dam and Sluices	2,011,984 11 8
Waste weir	84,362 1 4
Wing wall to do.	2,356 2 6
Wing wall as previously estimated	47,321 12 0
Grand Total....Rupees	2,223,824 11 6

A. BUCKLE, Lieut. R.E.,
Assistant Engineer for Irrigation.

(1) The cost of the Dam and Sluices constructed on the formula, top $= \frac{3}{10}$ h, middle $= \frac{5}{10}$ h, bottom $= \frac{7}{10}$ h, is as above, Rs. 2,011,984.

(2) The same dam constructed on Colonel Fife's formula of base = ·55 h, top $= \frac{1}{4}$ base, will be less in the proportion of 1,052 : 1,460, or $2{,}011{,}984 \times \frac{1052}{1460} = 1{,}449{,}730$.

	Rs.
Therefore the above Estimate on formula No. 1 will be	2,223,645
On Formula No. 2	1,661,391

J. W. PLAYFAIR, Lieut. Colonel, R.E.,
Superintending Engineer for Irrigation.

CALCULATIONS of Centre of Gravity of Dam for the Irrigation Scheme, at the extreme height of 123 *feet.*

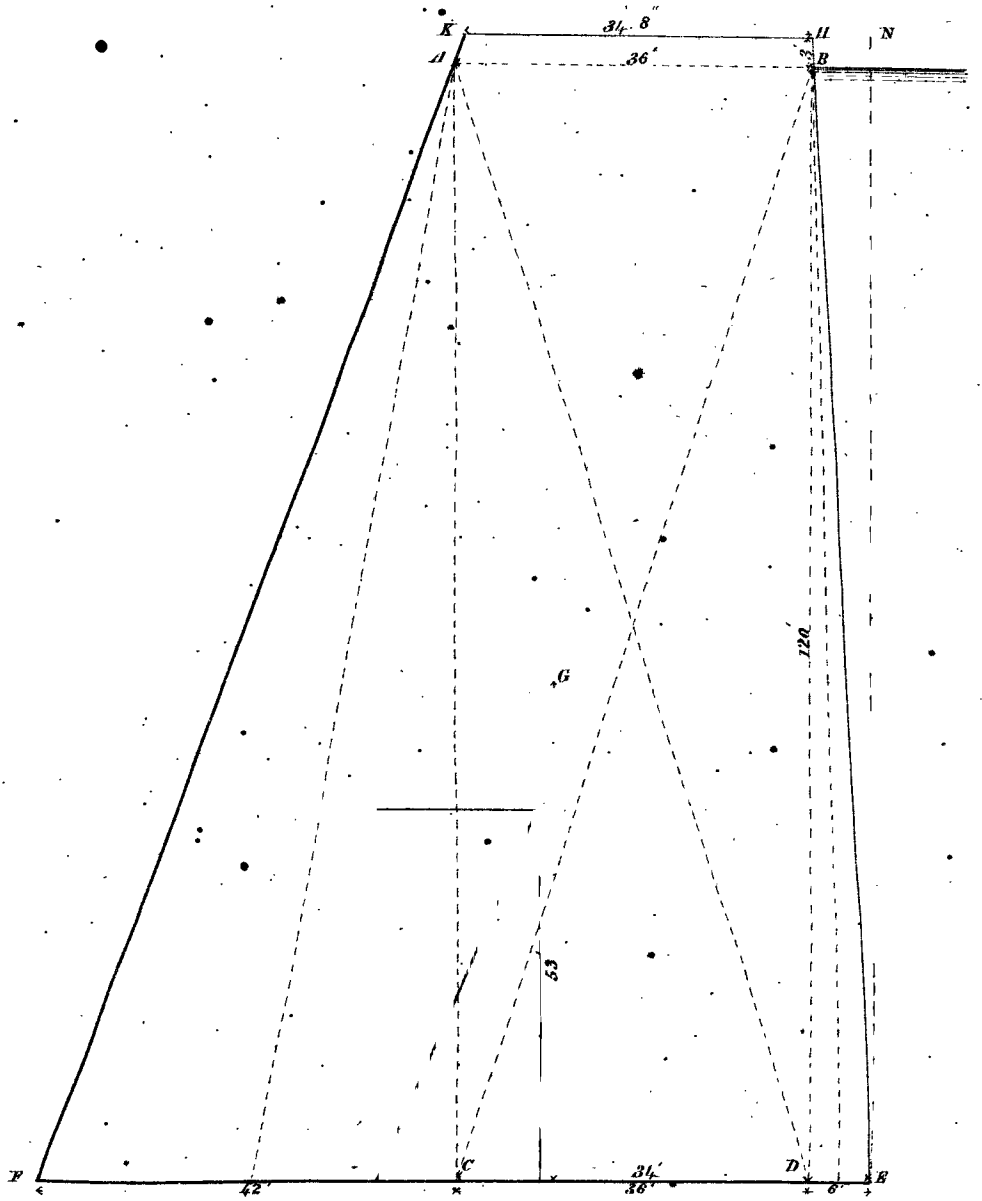
Area of top rectangle KABH	$= \frac{34{\cdot}3 + 36}{2} \times 3 =$	106·2
Area of rectangle ABCD	$= 36 \times 120 =$	4320
Area of △ AFC	$= 42 \times 120 =$	2520
Area of △ BDE	$= 6 \times 120 =$	360
Total area.....		7,306

Erect a perpendicular EN on EF at E, then the area of each separate figure × by the distance of its centre of gravity respectively from EF and EN will be equal to the area of the whole figure × by the distance of its centre of gravity respectively from the same lines.

Therefore let x be the distance of the centre of gravity of the whole figure from EF, then

$7{,}306 \times x = 106{\cdot}2 \times 121{\cdot}5 + 4320 \times 60 + 2520 \times 40 + 360 \times 40$
$= 12903 + 259200 + 100800 + 14400 = 387{,}303.$

POONA AND KIRKEE WATER SUPPLY.



(Sig^{d}) J. W. Playfair, Lieutt Colt R.E.

Super^{g} Engr for Irrigation.

$$x = \frac{387303}{7306} = 53$$

Let y be the distance from EN

$7306 \times y = 106{\cdot}2 \times 23{\cdot}7 + 4320 \times 24 + 2520 \times 56 + 360 \times 4$

$= 2517 + 103680 + 141120 + 1440 = 248757.$

$$y = \frac{248757}{7306} = 34.$$

Weight of water $= 120 \times 60 \times 62{\cdot}5 = 450000.$

Weight of masonry $= 7306 \times 150 = 1095900.$

Weight of water is to weight of masonry as 1 : 2·4 and acts at $\frac{1}{3}$ from the bottom.

Setting off a parallelogram proportionate to the above forces on the vertical of the centre of gravity the diagonal gives the resultant sought for.

J. W. PLAYFAIR, Lieut. Colonel, R.E.,
Superintending Engineer for Irrigation.

No. 1 of 1866.

Public Works Department.

To the SECRETARY to GOVERNMENT,
Public Works Department.

Sir,—I have the honour to acknowledge the receipt of your No. $\frac{822}{1975}$ of the 14th instant, forwarding for my report papers relating to the project for a Storage Reservoir on the Moota for Irrigation and Town Water Supply.

2. In January last, just before leaving Bombay, I supplied what I believe to be all necessary explanation on the subject of Colonel Scott's remarks on the section to be given to the Reservoir Dam. If a reference be made to the letter I then wrote, I think you will find that I showed that the conditions required by the principles laid down by Rankine were more than satisfied by the section I designed. In so important a question as the dimensions of a large Dam, I did not rest satisfied with merely adopting a general rule for thickness which did not make allowance for the difference in the material employed. I went into the *principles* of construction and worked out a result on the particular conditions of the case at Poona, just as Rankine himself would have done had he been designing a section for a particular case. Had the material intended for the Dam been brickwork, the dimensions worked out in this manner would have been different.

3. While showing the manner in which the dimensions had been arrived at, and that I had not set aside Rankine's principles, but had carefully attended to them, giving the section indeed some little advantage on the side of stability, I expressed my willingness to increase the thickness of the Dam as proposed by Colonel Scott. The increase was not great, and it could have been easily carried out during construction.

4. After this I expected that the progress of the project (which is most urgently needed) towards sanction would have been rapid. I regret however to find that notwithstanding all the exertion I made when in the Deccan, and the very severe fatigue which I un-

derwent while conducting double duties to get so important a matter concluded, the movement which has since taken place is one of retrogression and not of advancement. At the end of many months it has become apparent that Lieutenant Colonel Playfair, without any orders from Government, has been employing Lieut. Buckle in preparing plans and estimates for a kind of dam which is not approved by me, nor, as far as I can judge, by Colonel Scott either, and that the large irrigation project which was to comprise the smaller one for the water supply has been delayed. I left the surveys of that project in a very advanced state, and expected that about two or three months more only would be required to complete the plans and estimates. So closely did I expect it to follow the smaller one that the latter was only separately submitted on account of the urgency of the demand for water in Poona and Kirkee, and to enable Government to see how easily water for all purposes could be obtained in abundance, and with great economy, for both domestic purposes and irrigation.

5. The first portion of Lieutenant Colonel Playfair's letter No. 927, of the 30th July, relates to the manner in which the masonry for the larger project is to be connected with that of the smaller one. I must begin by informing you that Colonel Playfair is in error in saying that it occurred to me whilst preparing the water supply project to raise the dam and increase the storage for an irrigation project. The irrigation project was the original. Colonel Playfair is again in error in saying that my reason for submitting the water supply project separately was because the larger project would occupy a long time to prepare. I have already in a previous paragraph given my reasons for submitting the water supply project separately, and it is only necessary to look at the Government Resolution on the subject of the Moota project to see Colonel Playfair's first error.

6. With respect to the concluding part of Colonel Playfair's 2nd paragraph I would remark that it will be time enough to go formally into the question of how the masonry of the old and new work is to be connected when Government has decided what course to pursue. If the irrigation project is taken up it will be unnecessary to consider the matter at all, as the dam would from the first be carried up at its full thickness. The delay which is occurring

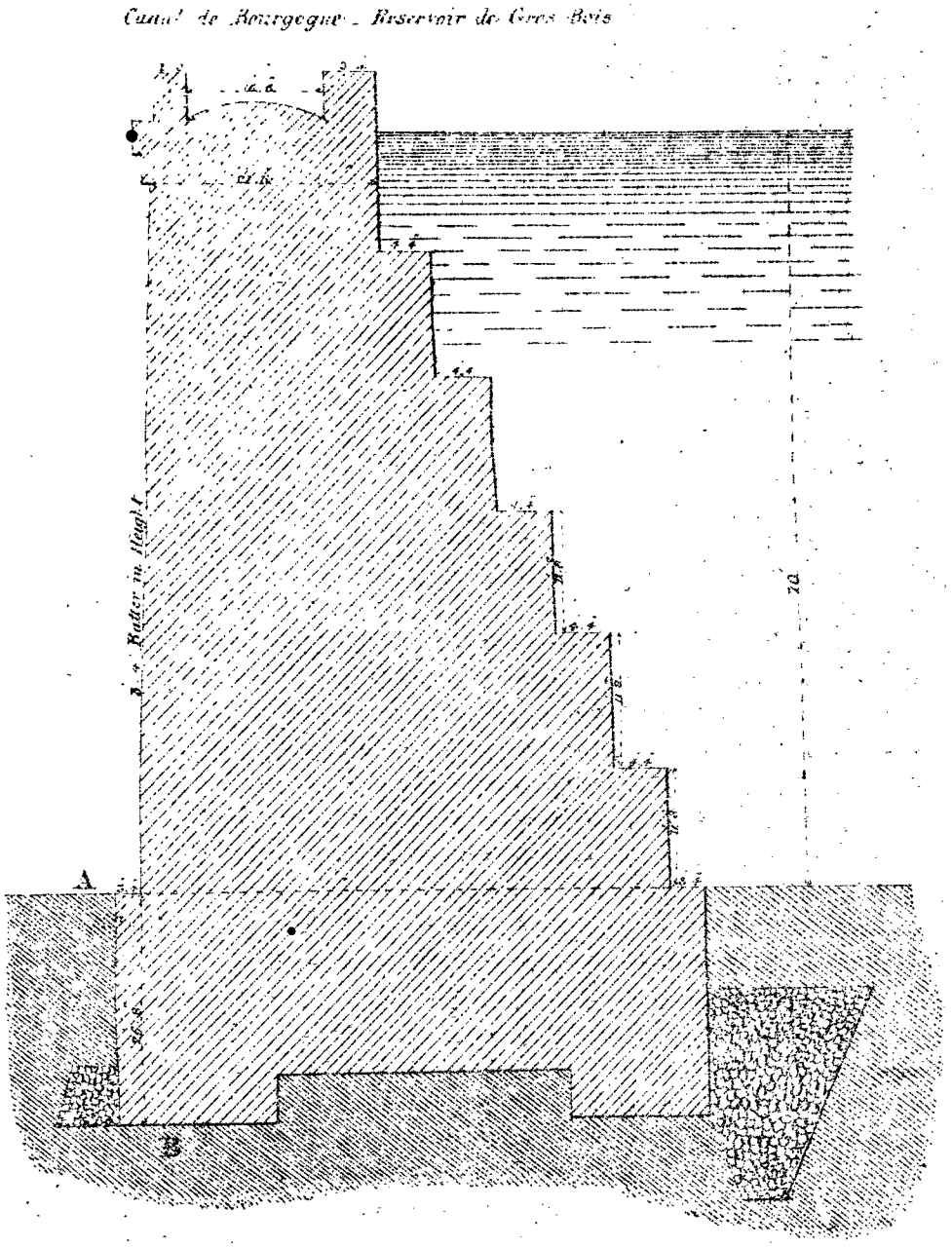
under Lieutenant Colonel Playfair in submitting the large project is producing the difficulty he dwells upon. In paragraph 36 of my report No. 860 A, dated 30th November last, recently published by Government, it will be observed that I say that the dam itself need not be made "higher" than is required for the water supply plan, but I do not say that it need not be made thicker. This part of my report is, I admit, not complete, as the mode of connecting the old and new masonry had not been, as well as I can now recollect, conclusively settled by me. It was in fact the very utmost I could do before leaving the Deccan for Sind to submit the project. I have merely to add now, that had Colonel Playfair submitted the complete large project within a reasonable time we should probably have been saved the trouble of considering the point at all. I have considered three modes of connecting the old and new masonry, but will not enter into a description of them here. If Government intend to carry out the irrigation project, the dam may be carried up with its full dimensions at once.

7. I will now proceed to the 2nd part of Colonel Playfair's letter, which treats of the section to be given to the dam. On this subject I concur generally with what Colonel Scott says. It is very desirable to have a massive work, but before we reject what is laid down by such well-known authorities as Moseley and Rankine, and incur an increased expenditure of many laks of rupees, we must be satisfied that they are wrong. Certainly Colonel Playfair has not established this. In the first place Colonel Playfair, though bold enough to condemn the design I submitted, and to advocate "the practical rule," which he says is contained in the *Aide Memoire*, has actually made the mistake of facing the dam the *wrong way*. The section given in the *Aide Memoire* has its batter on the water face, or inside the reservoir, but Colonel Playfair has by mistake got the batter outside. The calculations therefore given by him for the *Aide Memoire* section are erroneous.

8. In the second place the *Aide Memoire* rule makes no provision for difference in the nature of the foundation, whether soft or hard, and for difference in the quality of the material, whether light or permeable, such as brick-work ; or heavy and less permeable, such as good stone and lime masonry. So widely do circumstances differ that what Colonel Playfair calls a practical rule is merely a

rule to give a kind of average section which is useful in giving a general idea of the subject, but no further.

9. I would draw attention to the section given below, which is



taken from the article in the *Aide Memoire* Lieut. Colonel Playfair quotes. It is the section of a dam which sustains 70 feet in depth of water, and rests on a soft foundation.

This section is much heavier than the one I have given for the Moota, but its strength is not in the same proportion. I would suggest that Lieut. Buckle, with whom I left my original calculations, be requested to calculate the stability of this section of the dam of the *Reservoir de Gros Bois*, with the same data that I used, and then compare it with the section which was calculated on Rankine's principles by me. The soft foundation in the case of the *Reservoir de Gros Bois* makes the subject rather complicated for comparison, but Colonel Playfair or Lieutenant Buckle might give two calculations of its stability, one supposing the Dam to turn on its foundation at A, and the foundation unyielding and incompressible as if the dam were founded on rock; the other supposing the whole mass of masonry, including foundation, to turn on the soft foundation at B. In this last case it will have to be remembered that notwithstanding the precautions used of putting concrete or puddle on each side of the foundation the least that can be calculated on is that the ground will be damp and soft under the foundation. I would gladly make these calculations myself, but I cannot afford the time at present.

10. What gives the section on Rankine's principles so much strength is the skilful manner in which the masonry is disposed as compared to the clumsy sections which the rule Lieut. Colonel Playfair wishes to apply gives. I fear we are going back in Engineering instead of forward. I would recommend Lieut. Colonel Playfair to look at the section of the waste weir, 30 feet high, of the Kossurda Tank, as a specimen of what an officer of the corps produced 25 years ago. The section of that work is very like that given by Rankine, but it is slighter.

11. The object of the conclusion of Lieut. Colonel Playfair's letter is not apparent. What I believe is required by Government is the submission of the Plans and Estimates for the Irrigation Project with the least possible delay, and not a letter about them

to say that they involve drawing plans and calculations. Had I remained in the Deccan they would have been submitted long ago.

I have the honour to be,

Sir,

Your most obedient Servant,

J. G. FIFE, Lieut. Colonel, R.E.,

Acting Chief Engineer in Sind.

Kurrachee, 31*st August* 1866.

No. 887 M.

Government of India.

PUBLIC WORKS DEPARTMENT.

Military Works.

To the ACTING SECRETARY to GOVT. of BOMBAY,
in the Public Works Department.

Simla, 8th September 1866.

SIR,—With reference to previous correspondence and to the letters * marginally noted on the subject of water supply for Poona and Kirkee, I am directed to communicate the following observations and orders of the Government of India.

* No. $\frac{107 \text{ M.W.}}{526}$, dated 22nd March 1866.
No. $\frac{5^{2} \text{ C.W.}}{1288}$, dated 20th June 1866.
No. $\frac{637 \text{ C.W.}}{1547}$, dated 3rd July 1866.

2. In December 1864 the Bombay Government submitted a project for the water supply of the Poona Cantonment from a reservoir in the Ambeygaum valley, five miles to the south-west, at a cost of Rs. 7,55,538. The project was approved of by the Government of India as sound, but, in the face of the possibility of the troops being ordered to be removed from Poona to Kirkee, it could not then be definitely entertained. The cost was, however, deemed excessive as an outlay of Imperial funds for a single cantonment, unless some means were taken to make the public pay their share; and it was suggested that it might be undertaken by a private company, or by the municipality, Government agreeing to pay for the water supplied to the troops (*see* P. W. D. No. 387 M, dated 4th April 1865).

3. In March 1865 the Bombay Government sent up another project for the water supply of the station of Kirkee from a reservoir in the Pashan valley, about 3 miles to the west, at a cost of Rs. 2,73,238. The Government of India deferred a full reply

till the question of the force to be located at Kirkee was settled, but called for the details of the project in P. W. D. No. 363 M, dated 29th March 1865. The reply was received in April, in which it was stated that, as the demand for water was urgent, and the project one which could be extended to any number of troops, and in all respects very suitable, it was hoped sanction would not be delayed. Some important points of detail in the project had, however, still to be supplied, and it was not until 15th August that the Government of India was able to issue orders (No. 905 M). Sanction was then given to the project, remarking, however, on the large proportion of the supply, 60 per cent., given to the Government garden, the small scale on which the supply to the troops was calculated, the importance of arranging for some return in the shape of water rate for the supply to private persons, and the arrangements to be made for the security of the supply to the fortified post. The Secretary of State fully confirmed the views and criticisms of the Government of India in a despatch which was communicated to Bombay on the 17th February 1866, No. 201 M.

4. Inquiry having been made in June 1865 on the subject of steam engines which were supplied by the liberality of a Parsee gentleman to facilitate the supply of water to Poona, the Bombay Government replied in November that this was a temporary arrangement, and did not affect the permanent water supply question, but that a new project was in contemplation which would embrace the supply of the Poona and Kirkee cantonments, and afford a larger and better supply at less cost than the two projects before sent up. A report by the Sanitary Commission was also submitted. In reply it was said in P. W. D. No. 1335 M, dated 4th December 1865, that the new project would be awaited.

5. This contemplated new project has since been sent up prepared by Colonel Fife, according to which the cost of the whole water supply is to be Rs. 18,21,679. It, therefore, does not, as regards the contemplated outlay, answer the expectations of the Bombay Government as to being less costly than the previous projects.

6. Notwithstanding its great cost, nothing is said on the subject of obtaining a return in the shape of water rate for the

outlay. In fact the remarks of the Government of India and of the Secretary of State on this important subject are totally unnoticed. Nor is there any notice whatever taken of any of the other points on which the Government of India recorded remarks; unless in the brief mention (para. 4 of the Bombay letter No. $\frac{107}{526}$ M. W. of 1866) that the new project was to provide 20 gallons per head for every person, European and Native, likely to be located at Kirkee, the previous project having allowed only 15 gallons for Europeans and 5 for Natives, while the Government of India laid down 30 gallons for Europeans and "a fair proportion for Natives."

7. The Government of Bombay pressed strongly in its letter of 22nd March 1866 the urgency of the want of water, the excellence of the project, and the necessity for immediate sanction. And on the call made by the Government of India for the details of the project which had not been sent up, that Government urges in its letter of 20th June the same things, especially on the ground of the ability and experience of Colonel Fife, the projector, in such matters.

8. The special reasons given by the Government of Bombay for deciding that the first project for Kirkee was insufficient, are that it was discovered that the engines ordered out for the Powder Factory were *condensing* engines, and would require upwards of 400,000 gallons a day to work them instead of the moderate quantity (10,800 gallons) before calculated. Also that it would require 350,000 gallons of water per day to water the turf in the enclosure to keep down dust. At all events, it was considered by the Bombay Government that 600,000 gallons would be required for the Ordnance establishments, and the cost of the extra supply would be Rupees 2,72,452 in excess of the sanctioned sum, say—

For the Engines.....	350,000	gallons at	Rs. 1,58,930
For watering Turf	250,000	,,	,, 1,13,522
Total..	6,00,000	,,	Rs. 2,72,452

9. Referring to these large sums, the Government of India would, *first*, inquire why, if condensing engines require so much more water, it might not be better to get them changed to non-condensing, as the cost of this change would apparently not amount

to a lakh and a half of rupees; *second*, why it should be worth while to spend so much for watering grass when, possibly, it might be arranged to suspend the manufacture of powder at the driest season so as to avoid the dust; and, *third*, since the water used for condensing steam is not lost, why *that* water should not be used for watering the turf instead of providing an additional supply for the purpose.

10. Half a gallon per minute per horse-power is a usual allowance for the feed of a condensing engine,—that is, 30 gallons per hour, or 300 gallons per working day of 10 hours. Now the whole horse-power of all the engines for the Ordnance factories at Kirkee is to be 129. They will require, therefore, 38,700, or, say, 40,000 gallons of water per day for *feeding*. The water for condensing is usually reckoned at 10 times as much as for feeding. It would appear that the Bombay Government has in this manner got at its estimate of over 400,000 gallons a day. But it has not been noticed that the whole of the condensing water, barring waste, and at least one-fourth of the feeding water is got back again, and may be used over and over again as long as there is a sufficient store of water to allow of its cooling. On the other hand it is necessary in India to allow about double the quantity of condensing water on account of its higher temperature. Although, therefore, more water might be required for actual use, it might not be necessary to provide nearly so much on the whole if arrangements were made to store and use over again the condensing water.

11. Then for watering turf 350,000 gallons a day are estimated for. This is enough to cover 31 acres of land with a depth of half an inch of water daily, and it is three times as much as is allowed in the estimate for 50 acres of Government garden (112,500 gallons). It is true that the Government of Bombay does not take quite the full requirement, since the demands for the factory are cut down for this and the steam engines from 750,000 gallons to 600,000. But this hardly appears to be a sufficient reduction. Considering the cost of and demand for water, it is thought by the Government of India that 170,000 gallons a day on the average should be made to suffice both for the steam-engines and watering turf.

12. The Bombay Government gives the following estimate of the entire quantity of water required daily for Kirkee :—

	Gallons daily.
Ordnance factories	600,000
Government House and Garden.....	123,000
Remainder, said to be at 20 gallons a head for all residents, European and Native, present and prospective	211,665
Total, as at page 5 of Colonel Fife's project...	934,665

Considering what was said by the Government of India on the former occasion of the submission of the project for water supply at Kirkee, a reduction of 53,000 gallons may, perhaps, be allowed in the item of the Government garden. And the supply for persons and cattle for the existing population may be reduced to Dr. Leith's estimate of 160,000 gallons. Thus the immediate wants of Kirkee may be set down at—

	Gallons daily.
Ordnance Factories	170,000
Government House and Garden	70,000
Population and Troops.....	160,000
Total..	400,000

13. Now, if it be remembered that there are wells affording a supply of water which, however scanty, has heretofore been made to suffice for the wants of the place, there does not appear to be any ground at present for demanding more than an *additional* supply at the rate of 250,000 gallons daily. This supply is that which the sanctioned Pashan project was calculated to afford at a cost of Rs. 2,73,238.

14. It is to be remembered, too, that the Pashan project is quite a different drainage to the new enlarged project, and its execution would not at all interfere with the *ultimate* construction of the other; while there are obvious reasons for desiring that, ultimately, there should be more than one independent source of supply. Besides this, the early construction of some works for water supply may be necessary in order to get the new factories to work as soon as possible.

15. There is, however, an argument at page 2 (para. 5) of Colonel Fife's project which, though not specially urged by the Bombay Government, requires to be considered as adverse to the construction of the smaller tank. It is to the effect that, since so large a lake as that of Vehar, of 1,319 acres area and 1,592,236,889 cubic feet contents, has become impure from the action of the climate in the hot season, there is little chance of the smaller reservoir of Ambeygaun (for the Poona supply) of only 77 acres area and 48,154,093 cubic feet contents, escaping from similar contamination.

The proposed Pashan lake for the Kirkee supply is still smaller, being, though 100 acres in area when full, only 36,352,322 cubic feet of contents. The lake proposed for the larger project would be 3,360 acres in area when full, and 2,299,468,000 cubic feet of contents.

16. Now, in comparing the extent of the latter with that of the Vehar lake, it will be apparent that there is no such difference as to lead to the conclusion that the proposed lake will certainly escape from the contamination which the Vehar lake has suffered, if that contamination be due to want of sufficient size. So far, therefore, the argument seems to go against the larger project also. It may be admitted that the smaller reservoirs are more likely to become contaminated. But, if the risk be greater, the money risked is very much less. Further, it is hoped by the Government of India that some means may be devised for preventing the water in reservoirs from becoming bad. And, again, for the steam-engines and watering turf, at all events, it is probable that the water from the reservoir would be good enough.

17. From the foregoing observations it appears to the Government of India that it has not been fully established that the best course is now to abandon the sanctioned Pashan project in favor of the larger one.

18. The larger project now submitted by the Government of Bombay involves so great an outlay that the Governor General in Council is unable to sanction it, and is unable even to recommend it for the sanction of the Secretary of State till it is brought to a complete state, and the probability of its proving remunerative is fully established.

19. I am directed, however, to state that the Government of India is very far from desiring to discourage this project. On the contrary it seems to promise very well, and in an engineering point of view to be very skilfully and satisfactorily arranged so far as perfected. No plan is more likely to lead to the satisfactory attainment of a cheap and effectual water supply to the city of Poona and its adjacent cantonments than a project which shall combine with that object a scheme for irrigation on a considerable scale. But still the principles laid down by the Government of India and the Secretary of State require that, before such projects are undertaken, it should be fully shown that they will be remunerative as well as likely to be otherwise successful. Unless they are so, no scheme for providing funds for their construction on a large scale can be practicable.

20. There are two points in the larger project which may, perhaps, be noticed at this stage. The first is that of the dimensions of the dam for the lake, which is to be of masonry, and 88 feet high. A difference of opinion has arisen between Colonel Fife and the Superintending Engineer of the Southern Division, Colonel Scott, to whom the project had been referred for opinion by the Bombay Government. Colonel Scott's report is not sent up. He, however, considered that the thickness of the dam should be increased. In reply Colonel Fife quotes Professor Rankine, who lays down the principle that a dam in firm soil is quite safe when the centre of pressure is within one-fourth of the thickness from the centre of the base. Thus Colonel Fife has determined his dam. But Professor Rankine goes on to deduce a simple practical rule from the above theoretical principle, namely, that the thickness at base should be 60 per cent. of the height, and the thickness at top 15 per cent., when the front is perpendicular.* This practical rule gives somewhat larger dimensions than the theoretical one, and is, therefore, safer. It, therefore, should be adopted. Colonel Fife says of Colonel Scott's proposal, "It will not add very largely to the cost to increase its thickness to the slight extent mentioned, and, of course, if the Government desire it, the increase can be made, but I am

* It is very nearly so in Colonel Fife's design.

perfectly satisfied myself of the sufficiency of the section." He would, therefore, probably not object to the addition suggested.

21. The other point is that, in order to embrace irrigation as well as water supply to the city and cantonment, Colonel Fife proposes to add to the height of his dam, and to increase its thickness accordingly. The Government of India would suggest that on this point Colonel Fife may be asked to consider whether, instead of doing this, it would not be better to construct one or more additional reservoirs. 88 feet is a high dam. It may be admitted that the lake is narrow, and, therefore, its discharge would be less sudden than in the case of a breach of a wide lake; but, when there is a large city below, it will be better to have two or more reservoirs instead of leaving the safety of the project and of the neighbourhood to depend entirely upon the stability of a single dam. *Some* increase of height may be admissible, but the expediency of adding 34 feet to the height seems to require very full consideration.

22. Allowing that the project would be remunerative, the water supply of Poona, which, as Colonel Fife says, would require only about one-thirtieth of the entire supply available, would practically be got for nothing more than the bare cost of distribution, or about 4½ lakhs for the supply of 3 or 4 millions of gallons daily. In this sense it is quite true that the larger project would be *cheaper* for the water supply. But it would only be cheaper after an outlay for irrigation of 30 or 40 lakhs had been provided.

23. Colonel Fife is naturally anxious to be allowed to begin at once on his dam* before the details of the rest of the project are completed. This would, doubtless, save time, and so be advantageous. But, until the financial arrangements for irrigation works generally are settled, it does not seem possible to arrange this, and on principle it is undesirable to deviate from the rule of permitting no actual construction until projects are fully matured.

* Page 15, paragraph 39.

24. In conclusion, then, I am to state that the Government of India regrets to be unable, from financial reasons, and owing to the necessity for proceeding with system and caution in the exten-

sion of irrigation works, to give sanction to any immediate outlay on the very promising Kurrukswalla project, and would, therefore, desire the Bombay Government to reconsider the question of proceeding with the Pashan reservoir. If the Bombay Government should be able to recommend such a course and will supply the information the Government of India formerly asked for, the Governor General in Council will be prepared to consider it. But in the meantime no delay should be allowed to occur in completing the estimate for the Kurrukswalla project, both as to the works for irrigation and the probable income.

I have the honor to be,

Sir,

Your most obedient Servant,

C. H. DICKENS, Lieut. Colonel, R.A.,

Secretary to the Government of India.

Digitized with financial assistance from

H T Parekh FOUNDATION

An Initiative by HDFC

WITH YOU, RIGHT THROUGH

on 27 November, 2018